

Life Cycle Assessment (LCA) as a Design Tool for Sustainable Thermoelectric Materials, Modules and Systems

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Thermoelectrics are often cited as a sustainable technology for the energy transition. However, this claim is rarely quantified and there is a lack of tools designed for such quantification that could also be used to optimise sustainability.

In this study, Life Cycle Assessment (LCA) is used to evaluate the environmental impact of a thermoelectric system for industrial waste heat recovery based on full Heusler thermoelectric modules. The method proves effective in enhancing sustainability at different levels: (i) doping strategies to improve thermoelectric material performance, (ii) module manufacturing, including waste management and end-of-life consideration, and (iii) the impact of heat exchangers at the system level.

Comprehensive optimisation is shown to reduce most environmental impact indicators by a factor of 3 to 16 compared with the baseline scenario. The environmental impact per kilowatt-hour of electricity generated by the optimised thermoelectric system is significantly lower than the impact of the Belgian electric mix and even lower than Belgian wind power generation.

Finally, the proposed method is compared with established techno-economic analysis [1] to highlight similarities and differences between cost impacts and environmental impacts on thermoelectric generator design.

References

[1] S. LeBlanc, S. K. Yee, M. L. Scullin, C. Dames, K. E. Goodson, *Renewable and Sustainable Energy Review*, **32**, 313-327 (2014).

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